The Effects of Road Oiling on PCB Accumulation in Aquatic Life

LTS 80-5

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Ontario
Ministry
of the
Environment

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THE EFFECTS OF ROAD OILING ON PCB ACCUMULATION IN AQUATIC LIFE

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HAZARDOUS CONTAMINANTS
AND STANDARDS BRANCH
135 ST. CLAIR AVENUE WEST
TORONTO, ONTARIO M4V 1P5

by
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PREFACE

During the past few years there has been growing concern over the increasing numbers of fish contaminants in Ontario lakes and rivers. Many contaminants reach concentrations in fish which pose a risk for human consumption, while the health of the fish themselves does not appear to be affected. Consequently, human consumption of fish from some waters must be controlled because of their content of materials such as mercury or PCB's.

Effective major fish analyses programs have been directed toward the sport fish populations in order to develop appropriate human consumption guidelines. However, due to ageing difficulties and their wide-ranging life-style contaminant residue data of adult fish do not shed much light on some fundamental questions regarding contaminant control, such as location of sources, trends with time and mechanisms of uptake.

To augment the adult sport fish surveys, the Toxicity Unit began in 1975 to conduct contaminant surveys of young fish. The program concentrates on young-of-the-year, or yearlings of a variety of species. Such fish can be easily aged and they represent current contaminant uptake conditions. The young fish have a limited range, so their contaminant uptake represents also a narrow range of space conditions While the results may not be relevant to human consumption of sport fish from the same waters, they provide good scientific data for determining contaminant uptake as a function of time and geographic location.

This concept is being applied to investigate a number of areas of concern in the Province. The young fish surveys are supported by a variety of chemical and biological collections to suit the specific purpose of the investigation.

This report deals with the practice of waste oil use for dust control and its effect on PCB uptake in yellow perch and freshwater clams in the receiving waters.

Summary

PCB residue concentrations were determined in yearling yellow perch from twelve Muskoka lakes to evaluate the effects of road oiling on PCB uptake. Fish residue analyses have shown that PCB's were significantly ($P < 0.05$) elevated in lakes that were affected by the run-off from waste oil applications. Furthermore, 71% of all the fish samples analyzed from lakes affected by road oiling exceeded the PCB guideline for wildlife protection (I.J.C. 1977), while PCB residues in non-affected lakes were considerably lower.

A study using freshwater clams in Dickie Lake demonstrated that PCB uptake in the nearshore biota was affected by drainage characteristics and the proximity of waste oil application sites to the receiving waters. Although the PCB residue concentrations in waste oils applied were considerably below the Ontario Pollution Prevention Guideline of 25 ppm, a significant ($p < 0.05$) uptake of PCB's was observed in caged freshwater clams.

Stream sediment analyses showed that the highest PCB concentrations existed immediately below the oiled road in the stream bed.

INTRODUCTION

Although the practice of using contaminated waste oils for dust control is well established, little is known of the environmental impact associated with it. A report prepared for the Ontario Ministry of the Environment and Ministry of Transportation and Communications on the Effects of Waste Oil as a Road Dust Suppressant (L.S. Love & Associates 1978) concludes that runoff is the major route for transfer of waste oils from the road surfaces. Therefore, it can be expected that any contaminants in waste oils will eventually be discharged to surface waters. EPA's Water Quality Research Laboratory in Edison, N.J. (Waste Oil Fact Sheet) has also demonstrated that about 99% of the oils applied to rural road surfaces left the surfaces either as dust particles or in water runoff. While the waste oil movements were documented by both studies, the effects on the aquatic life in receiving waters have not been evaluated.

The presence of PCB residues in waste oils and the repetitive nature of road oiling in Ontario has raised questions regarding the possibility of PCB accumulations in the aquatic biota. The concerns over present road oiling practices have been documented by L.S. Love and Associates (1978), and the study concludes that the potential for receiving water contamination exists.

The present study was initiated following observations of anomalous PCB residue distributions in yearling yellow perch from Muskoka lakes.

METHODS

Fish Residue Investigations

In order to explain elevated PCB residues in fish from some Muskoka lakes used only for recreational purposes, PCB residue concentrations in fish from areas with known road oiling activities were compared with fish residues from lakes where oiling was not practiced. Twelve Precambrian lakes were used for the survey and were classified either as affected or not affected by waste oil applications (Fig. 1). Table 1. The criterion used for lake separation was the presence or absence of road oiling in lake drainage basins, as shown by township road oiling records. No attempt was made to quantify waste oil applications

TABLE 1. COMPARISONS OF PCB RESIDUES IN YEARLING YELLOW PERCH FROM OILED AND NOT-OILED WATERSHEDS

Locality	N*	Fish Size T.L. (mm)	Fish Weight (g)	% Fat	PCB Concentration (ng/g ± S.D.)
Not Oiled					
Cranberry Lake	7	106 ± 1	12.9 ± 3.5	5.2 ± 1.4	38 ± 16
Bigwind Lake	6	74 ± 6	3.6 ± 1.0	2.8 ± 0.4	10 ± 19
Chub Lake	9	82 ± 6	5.2 ± 1.3	2.4 ± 0.4	Trace
Leonard Lake	10	75 ± 3	3.9 ± 0.6	2.4 ± 0.9	Trace
Nelson Lake	10	82 ± 3	4.5 ± 1.4	2.1 ± 0.3	11 ± 12
Oiled					
Duck Lake	9	97 ± 3	8.2 ± 1.0	2.4 ± 0.5	79 ± 14
Healey Lake	10	83 ± 2	5.5 ± 0.5	5.0 ± 0.2	89 ± 45
Harp Lake	10	65 ± 3	2.4 ± 0.3	1.2 ± 0.1	101 ± 53
Fawn Lake	10	88 ± 4	6.3 ± 1.0	3.9 ± 0.4	146 ± 56
Little Clear Lake	10	70 ± 3	3.2 ± 0.5	3.3 ± 0.4	172 ± 67
Heeney Lake	10	79 ± 2	4.2 ± 0.3	3.0 ± 0.4	256 ± 84
Dickie Lake	10	67 ± 3	2.6 ± 0.4	3.3 ± 0.3	307 ± 70

*Each sample is a composite of 8 fish.

Detection Limit 10 ng/g

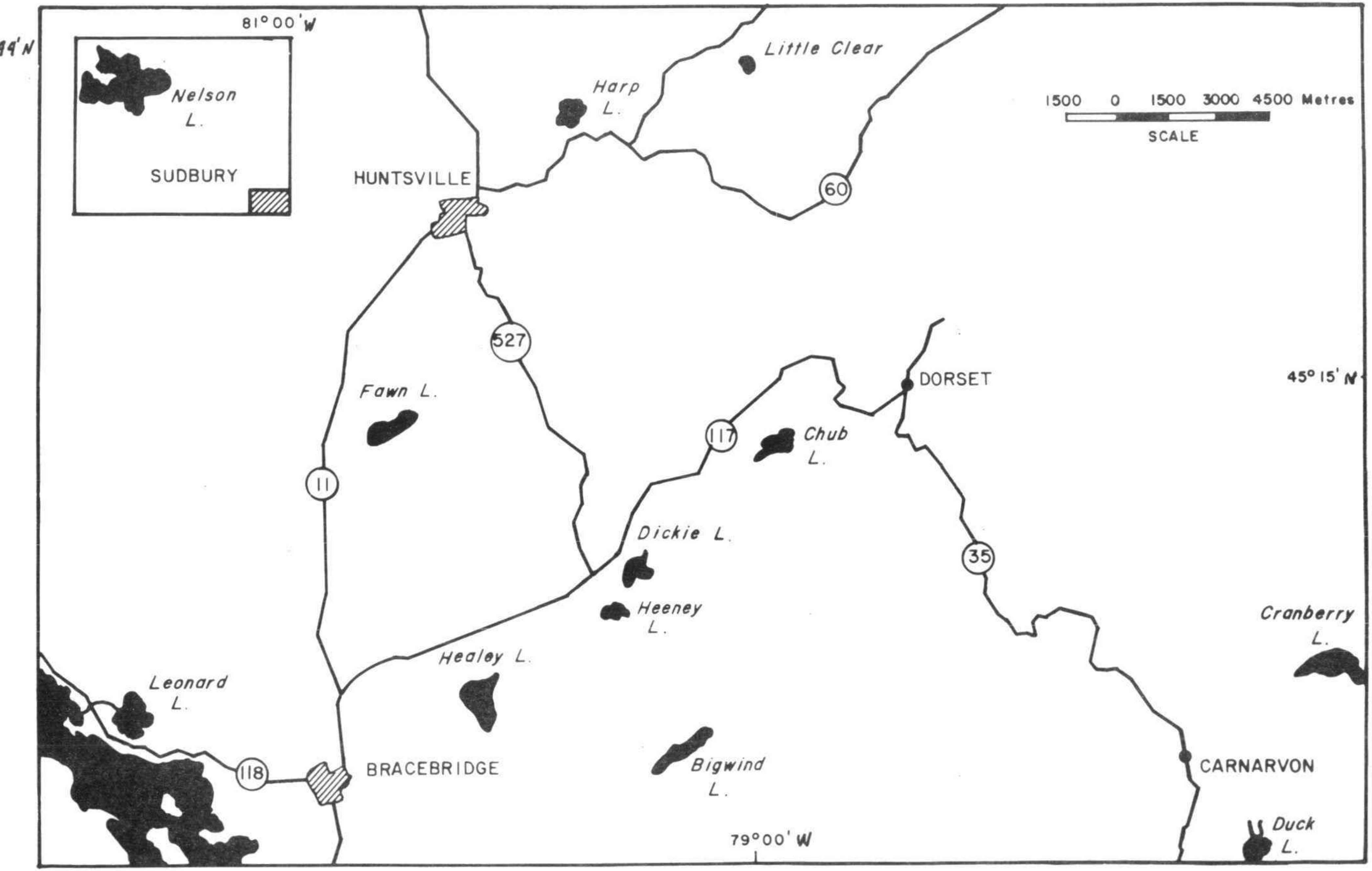

FIGURE 1 : STUDY AREA, MUSKOKA LAKES

in individual drainage basins.

Samples of young yellow perch (Perca flavescens) were collected for body-burden determinations. Individual fish were measured, weighed and scale samples taken from representative size groups. Fish ageing confirmed that all samples belonged to the yearling (1+) age class. The selection of a specific age class provided residue data that were spatially comparable. Composite samples of 8 fish each per site were wrapped in hexane-washed aluminum foil and frozen in the field. PCB residues were determined for composite whole fish samples, and analytical results were reported on a wet-weight basis. Student's "t" tests were done to compare differences between means. All analyses were done at the Ministry of the Environment Pesticides Laboratory at Rexdale by gas-chromatography methods. Detailed methodologies are available from the Handbook of Analytical Methods for Environmental Samples, Laboratory Services Branch, Ontario Ministry of the Environment.

DICKIE LAKE STUDY

Caged Freshwater Clams

In addition to the fish residue investigations, a study was undertaken at Dickie Lake in 1979 to assess site-specific effects of road oiling. Caged freshwater clams (Elliptio complanata) were used to evaluate PCB uptake at three nearshore sites in the lake (Fig. 2).

Live freshwater clams were collected from Balsam Lake in Bexley & Fenelon Township and transferred to Dickie Lake. PCB concentrations in Balsam Lake clams were typically at trace levels, and therefore may be considered representative of background conditions. Each clam was individually measured and weighed, and 15 clams were placed in each wire cage (22 x 21 x 15 cm). Caged clams were placed on lake sediments near Dickie Lake inflows #8, #9 and the lake outflow at locations C1, C2 and C3 (Fig. 2). Clams were located at site C1 adjacent to the oiled road on two occasions, first (June 5-19) prior to the season's oil application and secondly (June 19-July 10) after oiling. Road oiling was carried out on the 18th of June. The initial exposure was intended to evaluate PCB uptake from previous season's residuals.

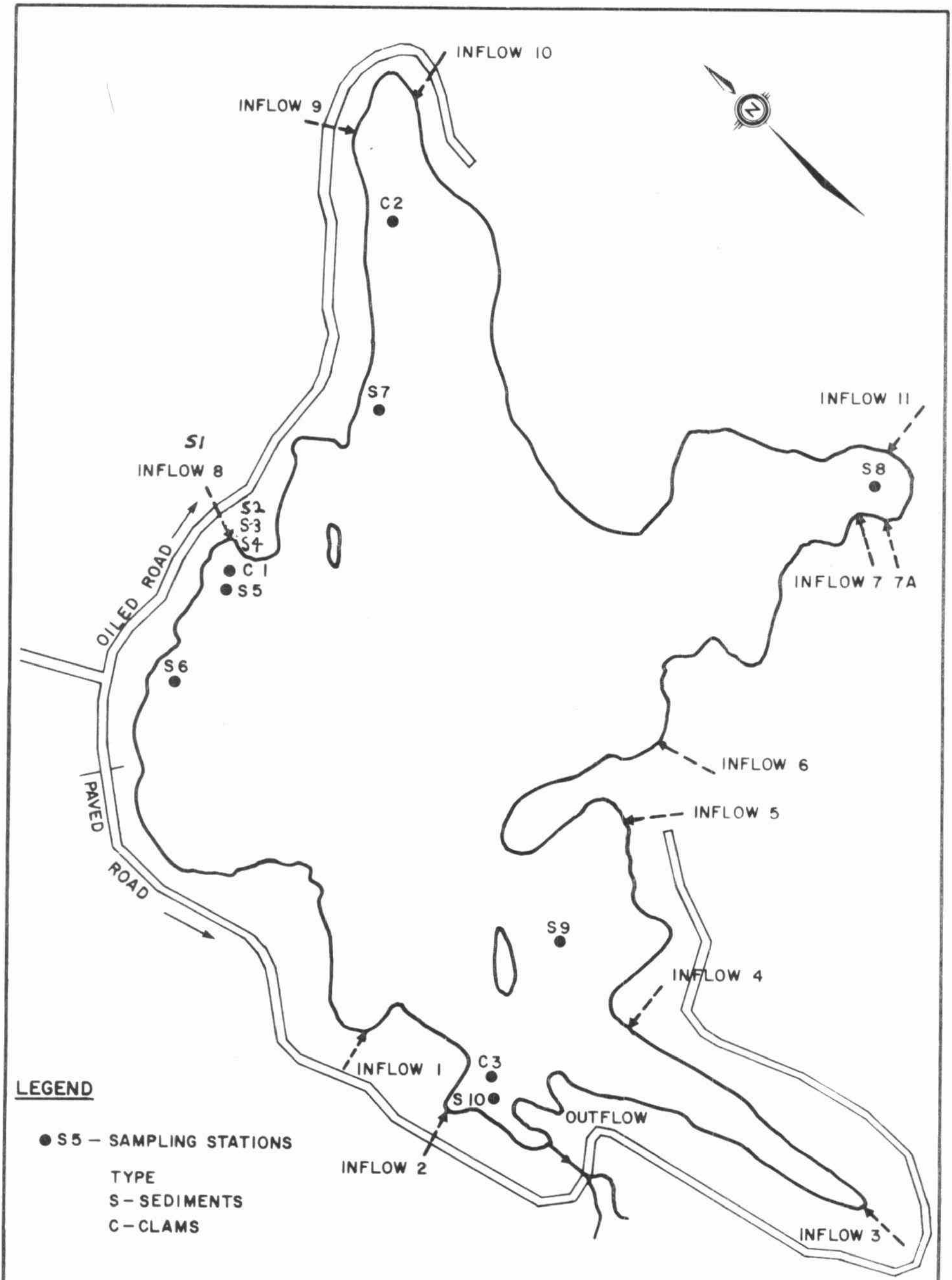

FIGURE 2 : DICKIE LAKE SITES

PCB's and fat content determinations were done by azeotropic distillation using benzene. Details of the analytical methodologies employed are available from the Handbook of Analytical Methods for Environmental Samples, Laboratory Services Branch, Ontario Ministry of the Environment.

Sediments

Sediment samples were collected at ten sites for PCB analyses (Fig. 2). Most samples were obtained with a 5 cm diameter push-rod corer of Water Resources Branch design, but Station S9 was sampled with a 23 x 23 cm ponar dredge. The control site (S1) was located about 50 meters upstream of the perimeter road on inflow #8 in a marshy area with very organic soils. Downstream from the road and around the perimeter of the lake the sediments were predominantly sandy with varying fractions of organic detritus. Some construction activity just downstream from the road (installation of a weir on #8 inflow) may have induced recent siltation in the stream, but visual observations revealed only minor silt deposits.

Station S9 in a deep sheltered basin was the only lake station sampled which represented a true depositional environment. Any contaminants in the nearshore sands would be indicative of fairly recent inputs that would ultimately be resuspended and transported to a depositional area.

Core samples were of varying lengths due to variations in sediment types and the inability of the push-rod corer to penetrate through roots, stones and clam shells. Cores were extruded directly into wide mouth glass jars, one sample for the top half of the core and one sample for the bottom half. Details of core lengths are given in Table 3.

In addition to PCB's, the sediments were analyzed for mercury, copper, zinc, lead, aluminum and nickel. All analyses were done at the Ontario Ministry of the Environment Laboratories in Rexdale.

TABLE 3. PCB RESIDUES IN DICKIE LAKE

SEDIMENTS - 1979

Station No.	Depth Interval	Description	PCBs (µg/kg)
Station 1 Upstream Control	Surface to 10 cm	Highly Organic	ND
	10 cm to 20 cm	Black Silt	ND
Station 2 Roadside	Surface to 5 cm	Brown Organics Sand with Roots	1000
Station 3 Stream half way to lake	Surface to 10 cm	Coarse Sand over Organic Silt	ND
	10 cm to 15 cm		200
	Scoop of Surface 2 cm	Loose Organic Silt	240
Station 4 Stream Mouth	Surface to 9 cm	Coarse Sand & Org.	ND
	0 cm to 20 cm	Med. Sand & Org.	20
Station 5	Surface to 12 cm	Medium Sand & Org.	20
	12 cm to 24 cm	over Fine Sand	ND
Station 6	Surface to 10 cm	Fine Sand Some Organic Debris	ND
	25 cm to 35 cm	Fine to Coarse Sand	ND
Station 7	Surface to 6 cm	Vegetation over Sand with Pyrites	ND
	6 to 16 cm	Sand	ND
Station 8	Surface to 13 cm	Sand with Trace Org.	ND
	13 to 26 cm	Fine Sand	ND
Station 9	Ponar Surface to 5 cm	Organic Silt Ooze	150
Station 10 Lake Outlet	Surface to 8 cm	Vegetation over sand	ND
	8 to 15 cm	Coarse Sand and Organic Debris	ND
Detection Limit			10

N.D. - Non detectable

RESULTS AND DISCUSSIONS

Fish Residues

Mean PCB residue concentrations in yearling yellow perch from lakes where road oiling occurred, ranged from 79 - 307 ng/g; whereas fish residues from lakes where oils were not used on roads as dust suppressant ranged from 3-38 ng/g (Table 1). The respective means for each group were 166 ± 100 ng/g and 12 ± 15 ng/g ($p < 0.05$). The typical composition of PCB residues in fish were Aroclors 1254 and 1260 in a 4:1 ratio.

Since metabolic rates, exposure times and contaminant concentrations govern contaminant uptake in fishes (de Freitas 1976; Nebeker 1975; Kelso and Frank 1974), a degree of uniformity of fish sizes, ages and lipid contents is necessary for valid spatial contaminant level comparisons. The use of yearling yellow perch as a biological integrator satisfies these criteria. The collection of a specific age class has ensured a similar exposure period, and the absence of statistically significant ($p > 0.05$) correlations between PCB residues in fish, their sizes and lipid contents suggest that PCB residue differences cannot be attributed to differences in metabolic activity. It may be concluded, therefore, that the major differences in PCB residue concentrations in fish were related to PCB availability.

The I.J.C. (1977) guideline (100 ng/g) for PCB's in fish, established for the protection of wildlife and fish-eating birds were exceeded in 71% of the lakes affected by road oiling, whereas fish residues in the non-affected lakes remained well below this guideline limit. PCB concentrations in yearling yellow perch from these recreational lakes were of the same order of magnitude as residues found in lakes with known industrial or municipal PCB inputs, such as Lake Simcoe and Lake Muskoka (Suns et al. 1978), or several industrialized sites on Lake Ontario (Trenton - 346 ng/g; Moira River - 308 ng/g; Cornwall - 138 ng/g).

While the fish residue data from this survey demonstrate that PCB inputs from waste oil applications have significantly influenced PCB residue concentrations in nearshore fishes of the receiving waters, the degree and extent of PCB accumulation in adult sportfish remains undetermined.

TABLE 2. PCB UPTAKE RESULTS IN CAGED FRESHWATER CLAMS

DICKIE LAKE - 1979

	Stn. No.	N	Clam Size (mm)	Clam Weight (g)	% Fat	PCB Concentration (ng/g)
Pre-Oiling	C1	5	73 ± 1	6.8 ± 0.7	1.0 ± 0.2	N.D.
Post-Oiling	C1	5	70 ± 1	6.6 ± 1.0	0.8 ± 0.2	19 ± 4
	C2	5	74 ± 1	7.9 ± 0.8	0.9 ± 0.2	15 ± 11
	C3	5	74 ± 4	7.3 ± 1.2	1.0 ± 0.3	Trace

N.D. - Non detectable

Detection Limit 10 ng/g

Caged Freshwater Clams

No PCB residue accumulations were detected in freshwater clams after a 14 day exposure at Dickie Lake inflow #8 (C1) prior to the 1979 road oiling activities (Table 2). Lack of PCB residue accumulations from previous season's oiling activities indicates that PCB inputs can be effectively reduced if alternative dust-control practices were implemented. Freshwater clam evaluation studies have shown that a 14 day exposure period is long enough to demonstrate a measurable PCB uptake (Curry 1977). Following the road oiling on June 18, and after a 21 day exposure, significantly higher ($p < 0.5$) PCB accumulations were detected in caged clams at site C1 (19 ng/g) and site C2 (15 ng/g), compared to site C3 (2 ng/g) at the lake outflow. Both sites C1 and C2 were exposed to runoff from waste oil applications, whereas site C3 was not. These results suggest that PCB residue runoff from oiled road surfaces affects PCB accumulations in the nearshore biota. The effects are site-specific, and it appears that PCB residuals from prior season's applications did not affect residue accumulations significantly. It is interesting to note that soil sample analyses from Dickie Lake road showed PCB concentrations ranging from 12.6 ppm - 20.0 ppm in the oils used in 1979. These levels were below the Pollution Prevention Guidelines (1978) level of 25.0 ppm, yet a significant uptake of PCB's by the freshwater clams was observed in nearshore waters.

Sediments

No PCB's were detected in the sediments at the upstream control site (S1), while elevated PCB concentrations were found downstream of the road, with the highest concentrations closest to the oiled road (Stn. S2), as shown in Table 3. The PCB residues found resembled a one-to-one mixture of Aroclor 1254 and 1260. PCB residues were still twice the detection limit at the stream mouth (S4) and about 60 metres down the shoreline (S5), in spite of the predominantly sandy nature of the sediments. No PCB's were detected at the other sandy nearshore stations including the bay near the lake outflow (S10). PCB residues from the deep basin sediments of the lake (S9) at 150 μg/kg showed convincingly that PCB's accumulate in the lake in association with the fine grain-sized material. In comparison the mean PCB concentration for Lake Ontario sediments, a lake with known PCB inputs, has been reported to be 57 μg/kg (Frank et al. 1979), while PCB residues for Lake Huron sediments ranged from 9-33 μg/kg (PLUARG 1978).

In order to determine the potential metals inputs from waste oil applications, metals residues from Dickie Lake sediments were compared to metals data from lakes not exposed to waste oil inputs. It was found that lead (<3-130 μg/g), copper (<3-24 μg/g), zinc (5-170 μg/g), nickel (<3-10 μg/g), mercury (<.01-.52 μg/g) and aluminum (1-10 mg/g) concentrations in Dickie Lake sediments were not outside the typical metals ranges found in other Muskoka lakes (P. Dillon, personal comm.). Therefore it may be concluded that waste oils were not a major contributor of metals in the Dickie Lake watershed.

CONCLUSIONS AND RECOMMENDATIONS

PCB residues in juvenile yellow perch were found to be significantly elevated in watersheds where waste oils were used for dust control, as compared to lakes where road oiling was not practised. Fish residue concentrations in 71% of all fish samples analyzed from lakes affected by road oiling exceeded the PCB guideline established for the protection of wildlife and fish-eating birds.

PCB uptake results from the caged clam study in Dickie Lake showed that PCB accumulations in nearshore biota were affected by drainage characteristics and the proximity of oiled roads to receiving waters. The caged clam study results also suggest that PCB residuals from prior season's waste oil applications do not affect residue accumulations significantly.

It should be noted that significant PCB accumulations in the near-shore biota resulted from waste oil applications that contained PCB residues below the existing Pollution Prevention Guideline of 25 ppm. Therefore the PCB content in waste oils should be reduced in cases where the receiving waters are affected by run-off from waste oil applications.

While this study has demonstrated that waste oil applications do enhance PCB uptake in the biota of receiving waters, the impact on the sport fishery remains unknown. A PCB residue survey of adult sportfish in selected Muskoka lakes is planned for the 1980 field season.

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